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Mr. Daniel C. Crane, Examiner
P.O. Box 1450
Alexandria, Virginia 22313-1450

Applicant/Inventor: Vincent Craig Olsen
Applicant's Address: 1618 Lenz Lane; Boise, ID 83712
Application No.: 10/718,013
Filing Date: 11/21/2003
Art Unit: 3725
Primary Examiner: Daniel C. Crane
Date Mailed: 08/30/2007

Applicant's Reply to Office Communication of 05/30/2007 "Rejection of Claims Over Prior Art" by way of Amendment and by way of Declaration.

DO NOT ENTER: /DC/

02/12/2008

The Applicant has reviewed the Examiner's objections and rejections in the Office communication of 5/30/2007 and also the references cited in view of the state of the art. The Examiner rejected claims 1 and 2 of the present Application (10/718,013) on the basis of being anticipated by Fuchs (3,004,584) and Leese (3,831,419) and that Fuchs and Leese taught the claimed method of the present Application. The Examiner did not list any other patent references cited in view of the state of the art.

The Applicant denies that Fuchs and Leese anticipated and taught the claimed method of the present Application. The Applicant believes the Examiner erred in rejecting the claims. The Applicant requests reconsideration of the Examiner's objections and rejections of the claims and further examination of the Application. Set forth in this reply is a summary of facts, a description of a pure bending moment, a description of the Application, an evaluation of Fuchs and its differences from the Application, an evaluation of Leese and its differences from the

Application, errors in the Office communication, and proposed amendments to claim 1 of the Application to further clarify its differences from the references.

SUMMARY OF FACTS

The Application was filed on 11/21/2003. The first Office communication was on 5/11/2005 and requested that the claims of the Application be restricted. The Applicant responded on 5/27/2005 and restricted the claims without traverse by withdrawing claims 3-7 and electing to proceed with claims 1 and 2. The second Office communication was on 12/07/2006 and rejected the claims over prior art. The Applicant responded on 3/02/2007 by way of a clarifying amendment and declaration. The third Office communication was on 5/30/2007 and rejected the claims over the prior art of Fuchs and Leese and is the subject of this present reply by the Applicant. The Applicant had a telephone interview with the Examiner Daniel C. Crane on 8/22/2007 regarding some of the differences between the Application and the references and some of the Applicant's questions.

The substance of the interview consisted of discussing the denial of the claims with respect to the references of Fuchs and Leese. Applicant said that Fuchs imparts compressive stress and non-pure bending moment stress to the work piece due to the edge gripping off-axis clamps. Applicant said that Leese does not use constant bending moment stress or constant bending rate, and that it uses edge gripping clamps. Applicant proposed amendments to claim 1 and Examiner was not certain that the Application supported those amendments. No agreement was reached as to the allowability or patentability of the claims. The Applicant mailed on

8/17/2007 some notes to the Examiner for the telephone interview including some rough sketched figures, but they were not received by the Examiner prior to the interview.

DESCRIPTION OF A PURE BENDING MOMENT

A bending moment can be created in a section of elongate materiel between two torque couples, or between a torque couple and a fixed end or opposing force, or between two offset forces, or between two centrally located forces that oppose two distally located forces. A bending moment tends to create stress and plastic deformation in an elongate material that is compressive and/or tensile in the direction along the elongate axis between the torque couples. The stress on the outside of the bend is more tensile and the stress on the inside of the bend is more compressive.

"A **pure** bending moment is a bending moment that evenly distributes the bending stress over the cross section of the material such that the deformation and stress concentrations are evenly distributed" (Application 10/718,013 page 4) over the cross section and throughout the bending section. A material with homogenous bending properties and a symmetrical cross section bent with a pure bending moment will have the half of the cross section toward the outside of the bend in tension and the half of the bend toward the inside in compression. The maximum tension will be on the line or plane of the material furthest to the outside of the bend, and the maximum compression will be on the line or plane of the material furthest to the inside of the bend. The center plane of the material will have no stress and no deformation and is commonly called the neutral plane or neutral axis. Below are diagrams and graphs of a pure

bending moment in an elongate material with a circular cross section. These are the same diagrams that represent the Application.

PURE BENDING MOMENT

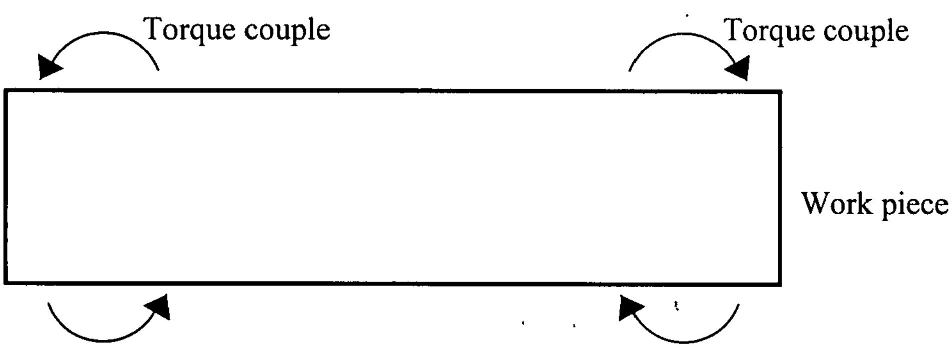


Figure 1. Work piece with two opposite torque couples creating a pure bending moment in the work piece.

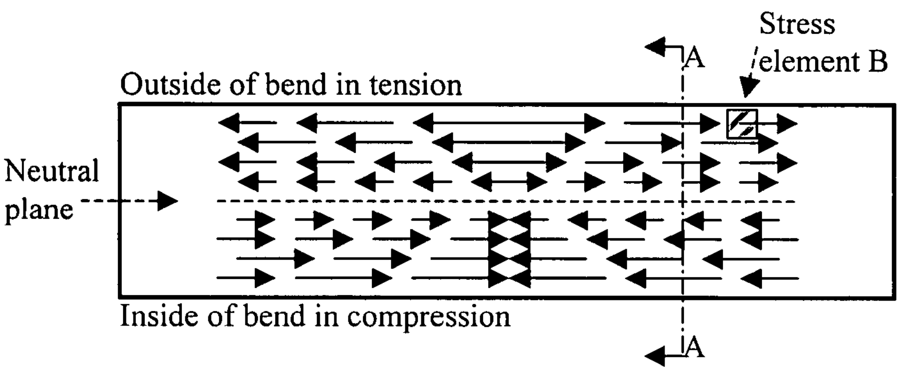


Figure 2. Direction of stress and plastic deformation in the work piece.

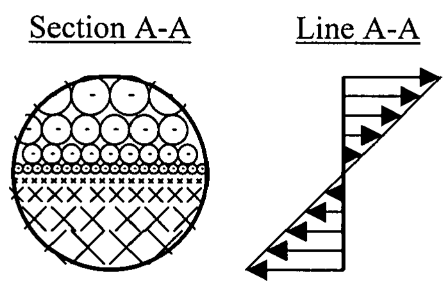


Figure 3. Distribution and magnitude of stress and plastic deformation over the cross section.

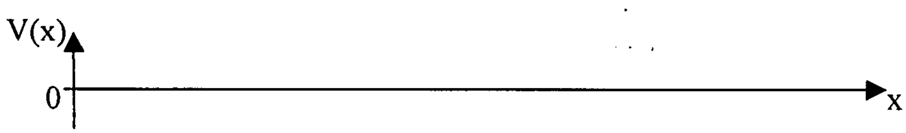


Figure 4. Graph of shear stress along the work piece as a function of length x. A pure bending moment does not create shear stress.

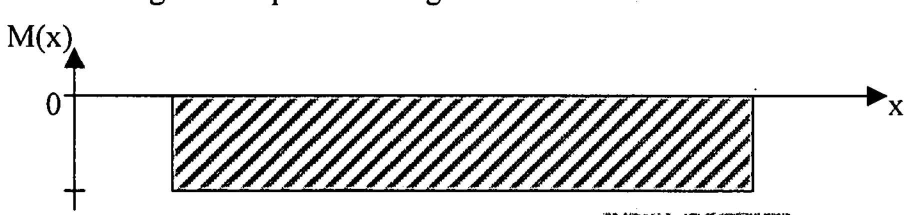


Figure 5. Graph of bending moment stress along the work piece as a function of length x. A pure bending moment is a horizontal line.

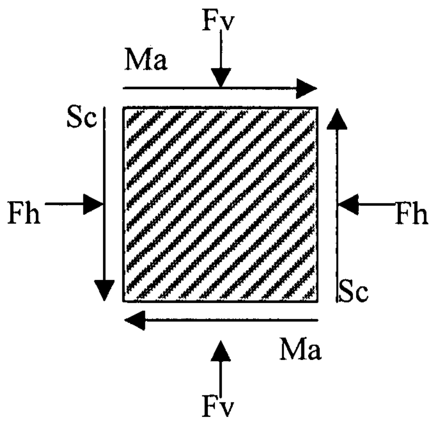


Figure 6a. A stress element shows all of the stresses on an element of the material in the plane of the element.

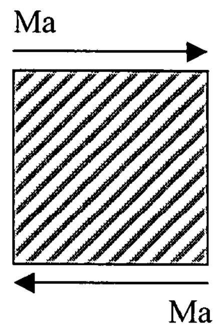


Figure 6b. Stress element B from figure 2. A pure bending moment in the absence of unneeded forces creates only moment stress along the axis of the material, so Ma would be the only stress on the element.

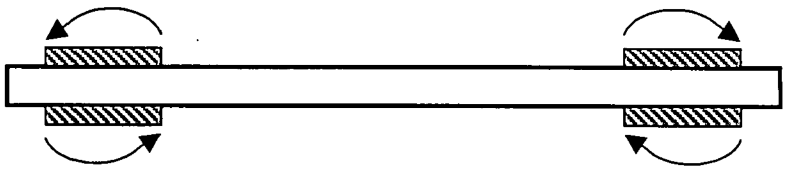
Figure 1 is a diagram of a work piece of round stock with a circular cross section that is subjected to a pure bending moment created by two opposite torque couples. Figure 1 is similar to drawing 1 of the Application. Figure 2 is a diagram of the same work piece of figure 1 that shows the direction and magnitude of the lines of force and plastic deformation in the work piece. The bending stress, and hence the lines of force and deformation, is between the two torque couples, and the portion of the work piece to the outsides of the torque couples has no stress on it and has no deformation. Figure 2 also shows section lines A-A and stress element B. Stress element B should be considered as being in the vertical plane of the center of the round stock, and not on the surface of the round stock. Figure 3 shows the direction and the magnitude of the lines of force and deformation across the cross section at A-A in figure 2. The X's in figure 3 are the tail end of arrows pointing into the cross section, and the circles are the heads of arrows pointing out of the cross section. As can be seen from figures 2 and 3, the magnitude of the axial stress from a pure bending moment is evenly distributed across the cross section, half in one direction and half in the other, and changes linearly from the outside of the bend to the inside of the bend.

Figure 4 and figure 5 are stress graphs. Figure 4 shows that a pure bending moment does not create shear stresses. Figure 5 shows that a pure bending moment has a bending moment stress graph that is a horizontal line. A bending moment in a beam that causes the top of the beam to be in compression is generally considered to be a negative bending moment, and that is why the graph in figure 5 is drawn with the bending moment stress being negative. Figure 6a is a diagram of a stress element and the possible stresses on the element, and Figure 6b is a diagram of the stress element B from figure 2. A stress element is a diagram showing all of the stresses on a small piece of material (an element) in the bending section. Vertical stress is Fv, horizontal stress is Fh and is compressive or tensile, shear stress along the face of the cross section is Sc, and bending moment stress along the elongate axis is Ma. A pure bending moment only creates bending moment stress along the axis, so the only stress in figure 6b would be Ma.

DESCRIPTION OF THE APPLICATION

The Application is drawn to a method of bending that will reduce the stress concentrations in the bent work piece as much as possible. The Application uses a pure bending moment to bend elongate material. The pure bending moment is created by two opposite torque couples that are parallel to each other and are applied to the elongate material through mid material non-slip contacts. The method of bending and the reaction forces of the Application are drawn below.

Figure 7. The work piece with mid material gripping clamps (cross hatched) applying torque couples.



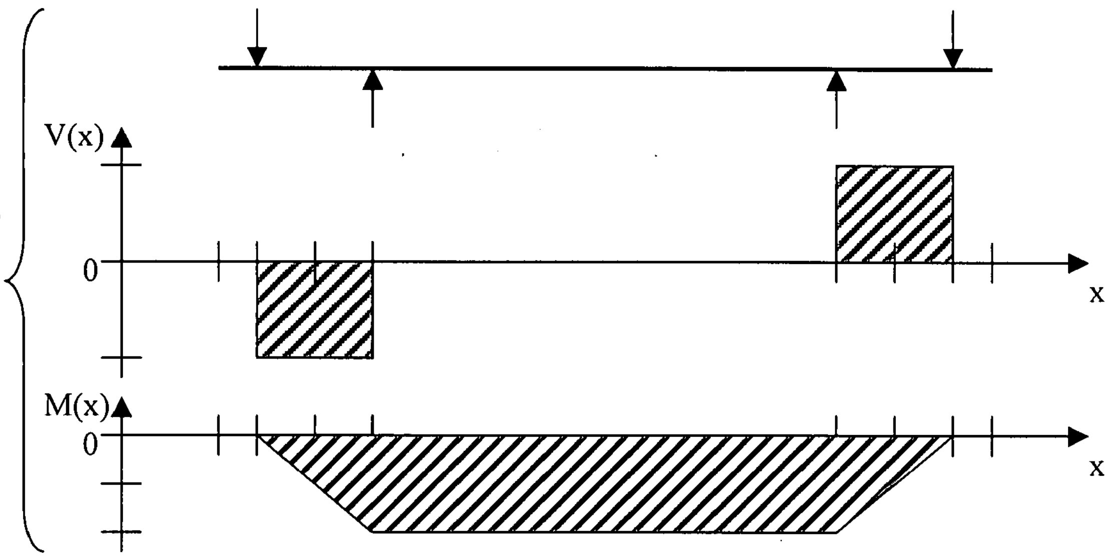


Figure 8. The reaction forces and shear and bending moment stress graphs of the work piece in loose clamps.

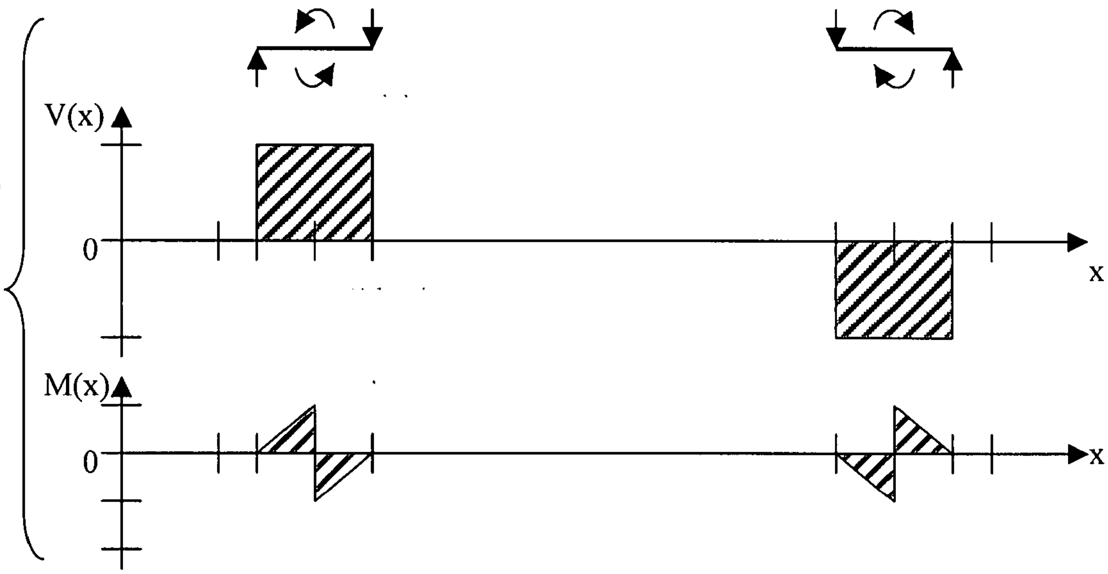


Figure 9. The reaction forces and shear and bending moment stress graphs of the mid material gripping clamps.

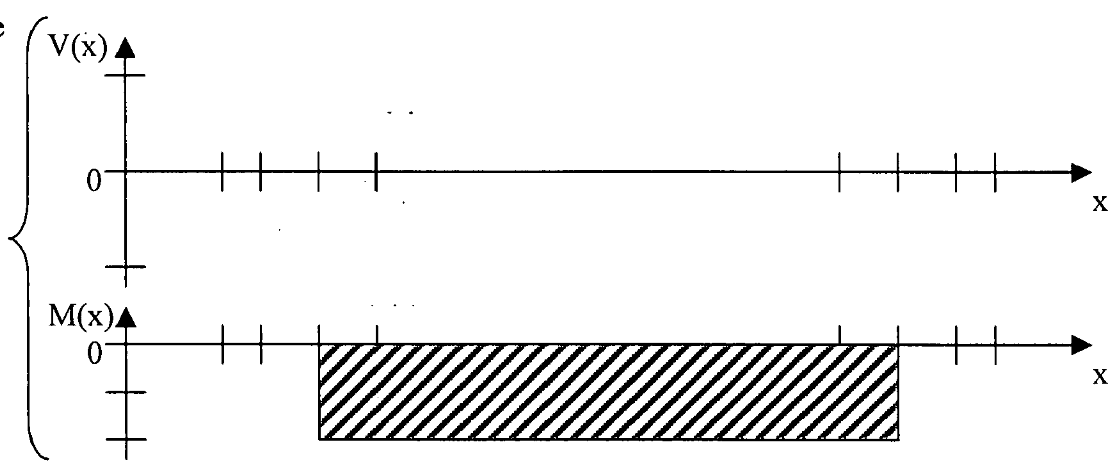


Figure 10. The shear and bending moment stress graphs of the work piece in tight, built-in clamps; the sum of the other two graphs.

THE MID MATERIAL GRIPPING NON-SLIP CONTACTS OF THE APPLICATION

The type and geometry of the clamp through which the bending forces are transmitted to the material is important because it affects the type of bending stresses in the material. Figure 7 shows the method of the Application with a work piece held in mid material gripping clamps that are transferring the bending couple to the work piece to create a pure bending moment in the work piece. Figure 8 shows the reaction forces on the work piece and the shear stress and bending moment stress graphs of the work piece if the clamp is loose. Figure 9 shows the reaction forces on the clamps and shear and bending moment stress graphs of the clamps if the clamps are loose. Since the mid material gripping non-slip contact clamps of the Application are not loose, but are determinant tight built-in type clamps, there is no play in the gripped portion of the work piece and the work piece and the clamps act as one part and the forces and stresses on the clamps and the work piece add together. Figure 10 shows the shear and bending moment stresses for the built-in, tightly gripped work piece of the Application. The graphs in figure 10 are found by adding the graphs in figure 8 to the graphs in figure 9. As can be seen from figure 10, the work piece of the Application does not have any shear stress and the bending moment stress extends from the axis of rotation of one of the torque couples to the axis of rotation of the other torque couple.

The non-slip contacts are configured such that they securely transfer the bending moment to the elongate material without creating shear stress; this is done by the non-slip contacts having a symmetrical geometry about the axis of rotation of the torque couple. This provides what can be considered a "built in" or "fixed end" determinant condition at the non-slip contact that resists all reaction forces, as opposed to a "pin", "simply supported", or "rolling" contact that would not

resist all reaction forces. The benefit of this non-slip contact is that the portion of the work piece in the contact or clamp is supported such that it does not have play or movement in the contact portion and that it does not have deformation in the contact portion, thus there are not created shear stresses in the contact portion of the work piece. The "material interface assembly 15 that **securely** holds the elongate material 1" (page 8) has a "material interface insert 21 is designed to act like a **cushion sandwiched** between the material interface frame 22 and the elongate material 1" (page 11-12) and "is designed to fit **snugly**... and **securely** around the elongate material 1" (page 12) with "a **snug grip**" (page 12) that is "**squeezed**... providing a **tighter grip**" (page 12) which creates "a **secure**... **grip** on the elongate material" (page 16).

The non-slip contacts center the axes of rotation of the torque couples such that they intersect the elongate material and intersect perpendicularly the elongate axis of the elongate material. The Applicant calls this type of contact "mid-material gripping" since the axes of the torque rotation intersect the work piece material. Only the work piece of a mid material gripping on-axis torque couple will "bend in response to **only** the pure bending moment" (page 5) when "material 1 is **inserted** into the material interface" (page 12) the "**required linear placement** of the material interface assemblies 15 **on** the elongate material before bending" (page 15). To utilize mid material gripping the "user then **slides** the elongate material 1 **into** the... material interface assemblies... **positioned** the required linear **distance apart** and the material interface bolts 19 are **tightened**" (page 12 and 16). The mid material gripping non-slip contacts then transfer to the elongate material torque "**couples** 2 that are **parallel to each other** and **parallel to the cross-section** of the elongate material 1" (page 16) and "are **configured** such that they create a **pure** bending moment... [and] the pure bending moment is the **only stress** on the bending

section 3" (page 16), which can only be accomplished with on-axis torque couples transferred through non-slip contacts.

THE BENDING PROCESS OF THE APPLICATION

The Application uses a constant bending moment that is specified as being created by gearmotors connected to torque increasing gearboxes. The motors are ran at a constant rate which creates a constant rate of rotation of the torque couples "that are **evenly rotationally displaced at equal rates** in opposite directions simultaneously… such that a pure bending moment is **maintained throughout the duration** of the bending process by **accommodating** the changing geometry of the deforming elongate material" (claim 1), and "the rotational displacement… is **equal in magnitude and rate at all times**" (claim 7). A control program calculates the bend formula and then controls the machine and "the rotational displacement of the two gearmotors" (claim 5) to perform that bend formula, which utilizes a constant rate of rotation. This creates a rate of bending and rate of angular displacement of the torque couples that is constant with respect to time and angular displacement as shown below in figure 11. Since the rate of bending is constant, the graph in figure 11 is a horizontal line.

The gearmotors create a constant torque that is increased by the gearboxes which put out a constant torque which is directly applied to the work piece through non-slip contacts and "**all of the torque** of the gearbox 12 can be **transferred to the material**" (page 9) such that a constant bending moment is created in the work piece. The Application utilizes constant torque in "a pair of torque couples of **equal magnitude** that are **evenly** rotationally displaced at **equal rates** in opposite directions simultaneously… such that a pure bending moment is **maintained**

throughout the duration of the bending process" (claim 1) such that "there is a minimum of stress concentrations in the elongate material caused by the bending process" (claim 2), which is constant torque since changing torque would cause extra fatigue and working of the material resulting in extra stress concentrations. The bending moment and bending torque are constant with respect to time and angular displacement as shown in figure 12. Since the bending moment is constant, the graph shown in figure 12 is a horizontal line.

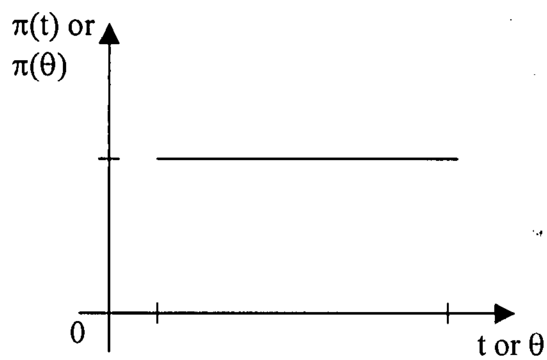


Figure 11. Graph of the rate of bending of the application over time.

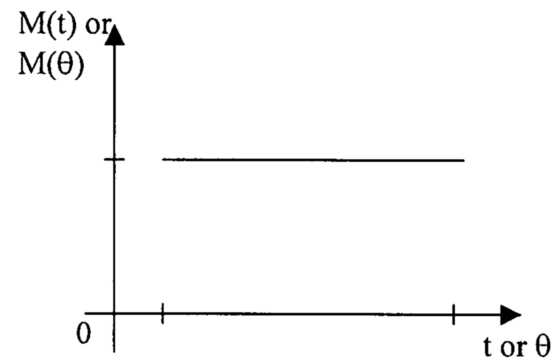


Figure 12. Graph of the bending moment of the application over time.

RESPONSE TO FUCHS (3,004,584)

The Examiner cites Fuchs as a reference that covers the same material as the Application and teaches the same method. The Applicant denies that Fuchs covers the same material as the Application and denies that Fuchs taught the same method that the Application claims. Fuchs is drawn to a machine and method that bends sheet metal in a variety of ways, primarily utilizing compression forces, to make 180 degree bends to form half cylinders and half cones.

SPECIFICATION OF FUCHS

Fuchs specifies a machine for "economically forming long panels and tapered panels" (column 1 line 12-13) in which the "panel is allowed to move bodily and freely during

bending… by forcibly bending rigidly gripped spaced portions of the panel" (column 1 line 27-29) that has rotary clamps and means for free or forced reduction of the lateral spacing between the clamps. Fuchs also describes having multiple pairs of clamps spaced longitudinally side by side for creating varied bending. Each clamp "support assembly may be said to have four degrees of freedom comprising rotation about a vertical and a horizontal axis, and linear translation of the support assemblies along two horizontal axes" (column 1 line 59-63). The clamps are capable of outward pulling and inward pushing and the machine is capable of flattening V shaped extrusions, which is not the type of bending of the Application. Fuchs describes the rotary arms as rotating "in a generally upward direction" (column 2 line 47).

Fuchs seems to have erred in the design of the lateral way 24. The clamp assemblies roll toward each other on lateral way 24 with rollers 29 and 32 designed to engage both faces of the guides 27 and 28 to limit lateral displacement due to reaction forces, but if the rollers contact both sides of the guides, then they will not roll, and if there is a space and they don't touch both sides, then not all of the lateral displacement will be limited. Fuchs also seems to have erred in the design of the upright annulus 20. The clamp assemblies are supported in the upright annulus 20 by six cam rollers 38 and two off center rollers 39. Since the rollers 39 are off center of the reaction forces, the rollers 39 will not limit displacement due to inward thrust and torsion of the clamp assembly. The roller is not inline with the center of the clamp and thus not inline of the reaction forces of clamp, and as designed cannot resolve all of the reaction forces.

Fuchs specifies that each of the opposite pairs of supports and clamp assemblies is "freely movable longitudinally on ways 124" (column 4 line 11-13) which is an extra axis of movement

not required for a pure bending moment. If there were movement of the clamps in the longitudinal direction (which is along the cross section for Fuchs), then it would not be a pure bending moment. Fuchs also specifies that the machine can be used to bend tapered pieces of sheet metal for producing half cones, which would not be a pure bending moment. The tapered sheet metal is not elongated in the same direction as that in the Application, and hence it is not a uniform cross section throughout the bending section. Fuchs specifies that the "rotary arms 12 extend downwardly and slightly outwardly" (column 4, line 34-35), which is not a pure bending moment, but off-axis compressive force. The "motions can vary along the panel as between various pairs of clamps and they can vary as between the opposite clamps constituting… the predetermined amount of rotation of the clamps or in the distance between the clamps of one pair" (column 5 line 13-18) which is not a pure bending moment. Shot peening is carried out because Fuchs states that it "has the advantage that the damaging tension stress is changed to a beneficial compression stress" (column 5, line 65-67), but as can be seen in the figures 14 and 15 below, there is more compressive stress in the material than tensile stress.

Fuchs specifies that the rotary clamps transmit torque or moments to the work piece, but Fuchs does not specify a pure bending moment as the Application does, and Fuchs does not specify a machine that could produce a pure bending moment. Fuchs does not specify torque couples with axes of rotation that intersect the elongate axis of the work piece as the Application does. The Application claims mid-material gripping contacts that can be placed anywhere along the elongate axis of the material and make bends of varying dimensions in various places along the elongate material, but Fuchs specifies a machine that only grips the edge of the material and

can only make bends across the whole length of the work piece and cannot be used to make various bends over the length of the work piece.

CLAIMS OF FUCHS

Fuchs claims a machine having forced lateral translation and free longitudinal means of translation and two axes of rotation for forming a panel using multiple pairs of rotary edge gripping clamps with independent operation. Fuchs claims a method forcibly rotating multiple edge gripping clamps and allowing the gripped edge portions to pivot freely about a vertical pivot axis and a lateral pivot axis with forced lateral translation between the opposing clamps and free longitudinal translation between pairs of clamps side by side with shot peening following the bending process.

Fuchs does not claim a pure bending moment or any other bending moment. Free reduction of the space between opposite clamps is not claimed, only forced lateral reduction is claimed. Fuchs does claim free longitudinal translation during the bending process, but a pure bending moment would not create translation in the longitudinal direction. Fuchs claims two degrees of translation and two degrees of rotation, which are more than are required for a pure bending moment. The Application has only one degree of translation and no degrees of rotation.

ANNALYSIS OF FUCHS

Fuchs does not utilize a pure bending moment. Fuchs does not utilize a bending moment in the absence of other stresses. The machine and method that Fuchs describes utilizes primarily axial compression. The clamps apply pressure to the work piece in the direction along the axis,

which is compression. The clamps swing through an arc and the work piece is tangent to the arc, and thus the clamps apply compressive forces to the work piece that come out of the clamps tangential to the axis of rotation of the clamps. The clamps that Fuchs utilizes apply the forces to the work piece in a manner that does not have the axis of rotation of the clamps intersect the work piece and does not intersect the axis of the work piece, but is offset from the work piece. This is not the type of mid material gripping non-slip contact that the Application describes and claims.

Fuchs uses a different geometry of clamp than the Application and applies different forces to the work piece than the Application. Consequently, the diagrams of the forces, force line distribution, and stress graphs for Fuchs are different than the Application. Below are figures describing Fuchs.

DIAGRAMS OF FUCHS

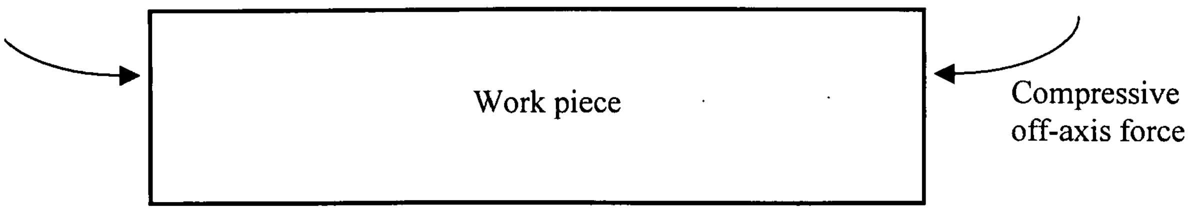


Figure 13. Work piece with two opposite off-axis compressive forces. The reaction forces are a portion vertical, but mainly horizontal and compressive.

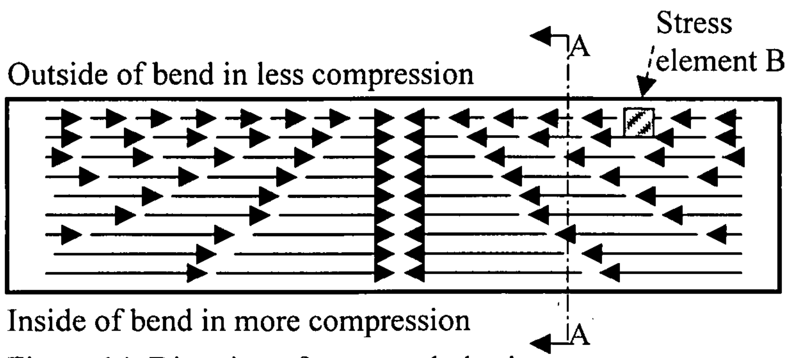


Figure 14. Direction of stress and plastic deformation in the work piece.

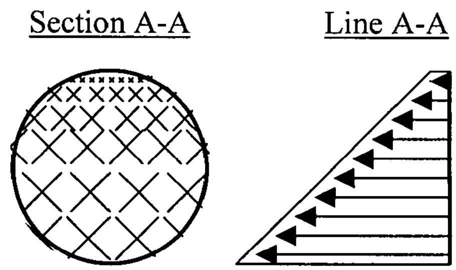
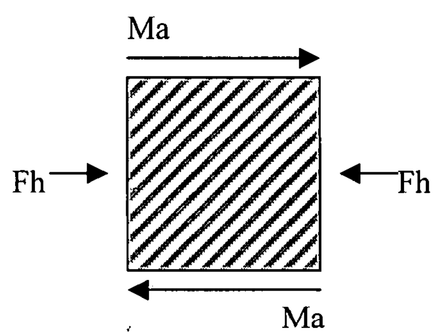


Figure 15. Distribution and magnitude of stress and plastic deformation over the cross section. Uneven distribution is not a pure bending moment.

Figure 16a. Stress element B from figure 2. Fh would be the largest stress, but there would also be Ma. Fv and Sc would be zero.



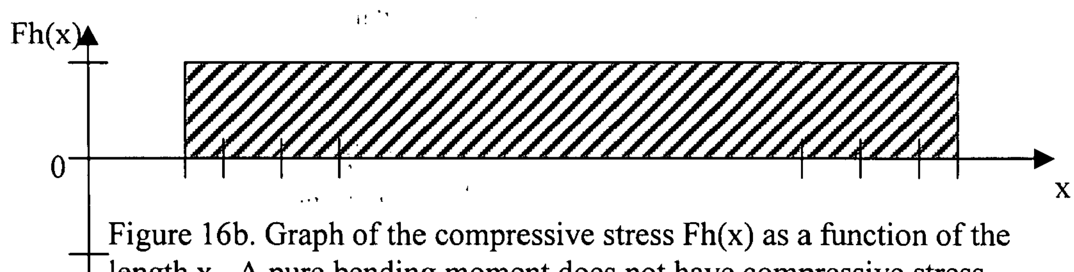


Figure 16b. Graph of the compressive stress Fh(x) as a function of the length x. A pure bending moment does not have compressive stress.

Figure 17. Work piece with edge gripping clamps (cross hatched) applying torque couples and axial compression.

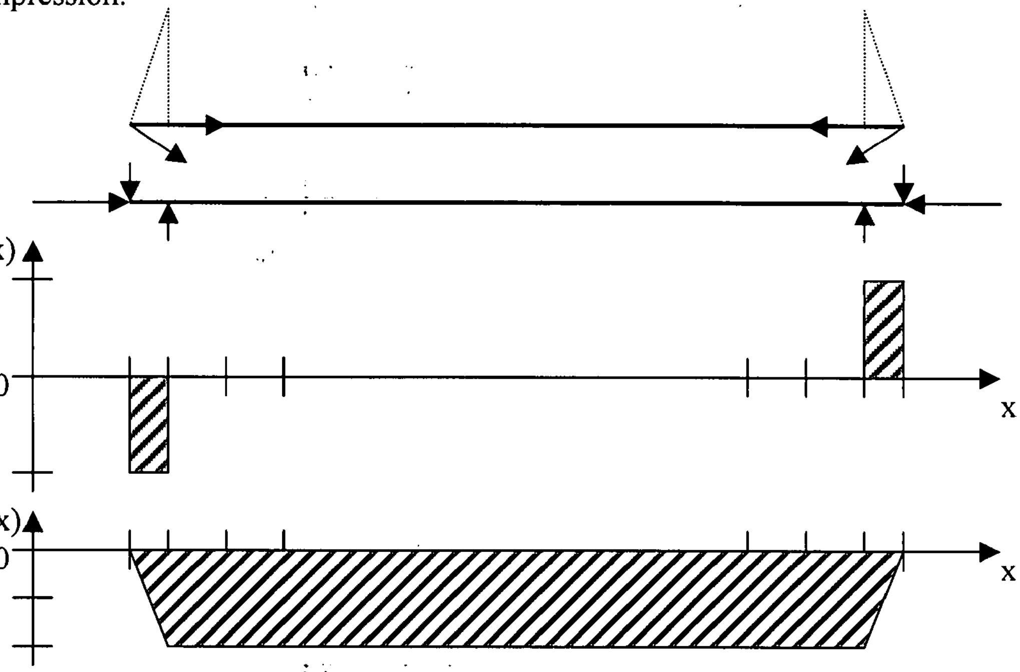


Figure 18. The reaction forces and shear and bending moment stress graphs of the work piece in loose clamps.

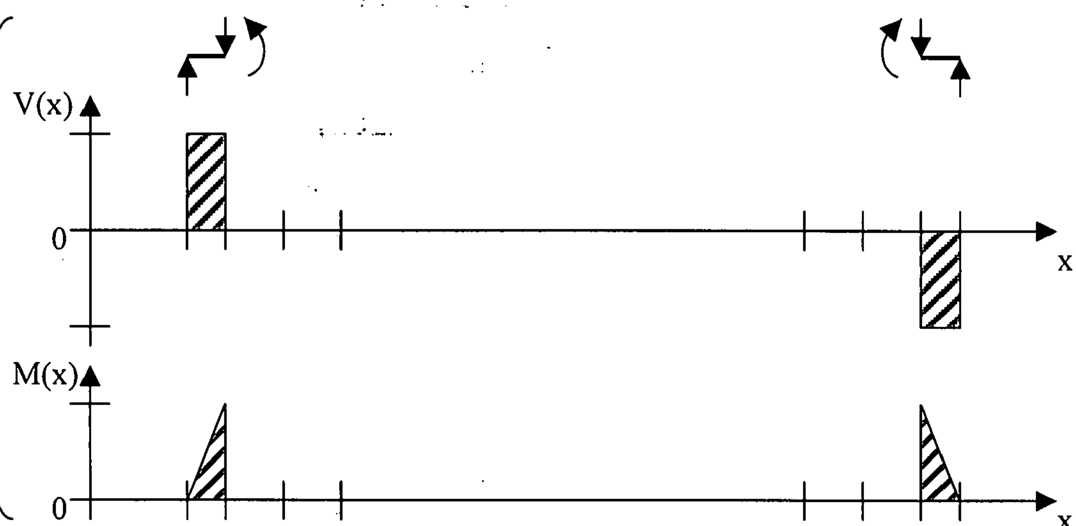


Figure 19. The reaction forces and shear and bending moment stress graphs of the edge gripping clamps.

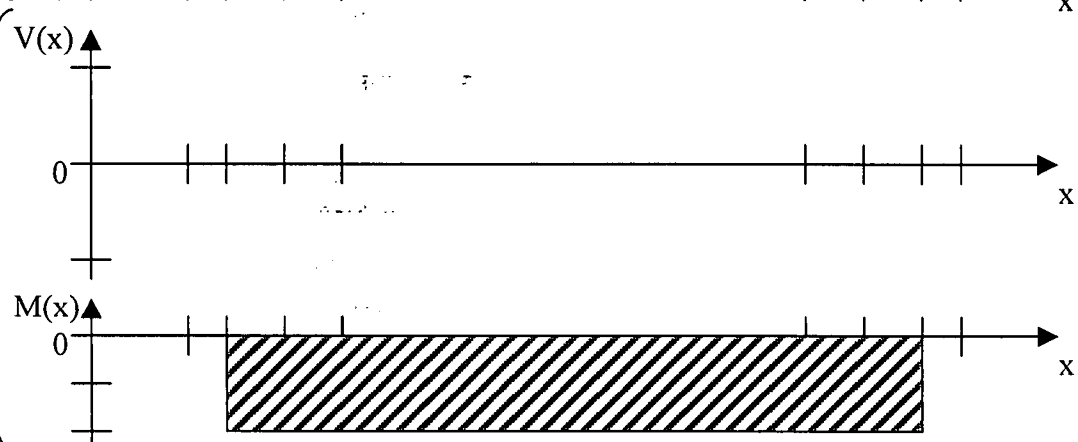


Figure 20. The shear and bending moment stress graphs of the work piece in tight, built-in clamps; the sum of the other two graphs.

Figure 13 is a diagram of how the forces intersect the work piece in Fuchs. The rotary clamps 12 exert forces on the panel 10 that are mainly axially compressive. The axis of rotation of the rotary arms 12 does not intersect the material and does not intersect the elongate axis of the material as also shown in figure 21. Fuchs specifies that the "rotary arms 12 extend downwardly and slightly outwardly" (column 4 line 34-35), which is shown in figure 21. Figure 18 is a diagram of the same work piece of figure 13 that shows the reaction forces on the work piece. The forces on the work piece of the Application in figures 1 and 8 are different than the forces of Fuchs in figures 13 and 18.

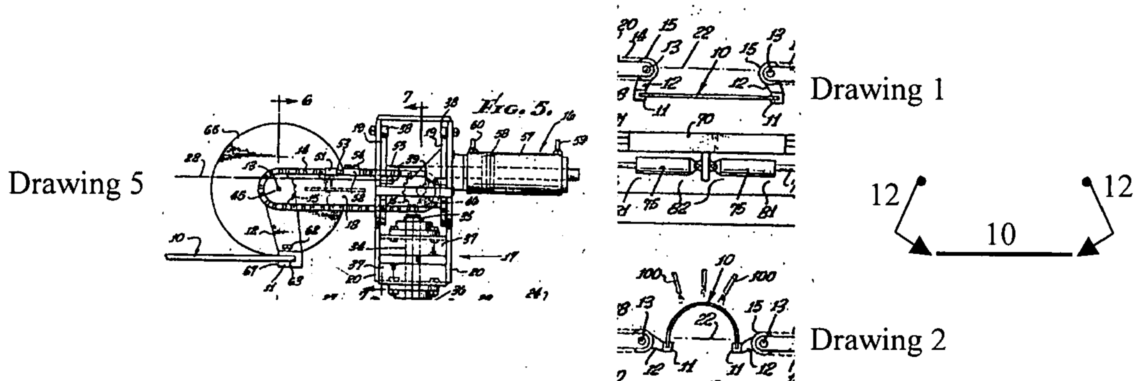


Figure 21. Drawings 1, 2, and 5 of Fuchs

Figure 14 is a diagram of the same work piece of figure 13 that shows the direction and magnitude of the lines of force and plastic deformation in the work piece. The bending stress, and hence the lines of force and deformation, is from almost edge to edge due to the edge gripping clamps 11. It is easily apparent that the lines of force of the Application in figure 2 are different than those of Fuchs in figure 14. The lines of force in the Application do not extend all the way to the edge of the material, but only from the center of one torque couple to the center of the other torque couple. Figure 14 also shows section lines A-A and stress element B. Stress element B should be considered as being in the vertical plane of the center of the round stock, and not on the surface of the round stock.

Figure 15 shows the direction and the magnitude of the lines of force and deformation across the cross section at A-A in figure 14. The X's in figure 15 are the tail end of arrows pointing into the cross section. It can be seen that the lines of force of the Application in figure 3 are different than the lines of force of Fuchs in figure 15. The Application has the bending stress half in tension and half in compression and the lines of force are perpendicular to the cross section. Figures 14 and 15 show that the bending stress in Fuchs is not distributed evenly across the cross section and that the stress distribution is not symmetrical, it is more compressive than tensile, and thus is not a pure bending moment.

Figure 16a is diagram of the stress element B from figure 14. There are compressive stresses Fh and moment stresses Ma. The stresses on an element add to each other to create a combined stress on the element. The more stresses applied to the element the greater the combined stress on the element. The element in figure 6b of the pure bending moment would have less combined stress on it than that in figure 16a since there are fewer stresses applied to it.

Figure 16b is a graph of the sum of the compressive stress on the work piece along the elongate axis as a function of length x. The graph shows that the there is compressive stress along the whole length of the work piece. A pure bending moment does not have a sum of compressive stresses that is other than 0.

Figure 17 is a drawing of the work piece 10 and of the off-axis edge gripping 11 rotary clamps 12 and the torque couple on the clamps. Figure 18 has two diagrams of the work piece 10, the

top one shows the angles of the forces acting on the work piece and the bottom one shows the reaction forces on the work piece, and it can be seen that the reaction forces line up with the inside edge of the clamp and the outside of edge of the work piece and the horizontal forces compress the work piece. Figure 18 also has graphs of the shear stress and bending moment stress of the work piece if it were in loose clamps. Figure 19 is a diagram of the reaction forces on the clamps 12 and 11, simply represented by one horizontal line each. The vertical reaction forces resist the torque couples toward the inside of the clamps. Figure 19 also has shear stress and bending moment stress graphs of the clamps that depict the differences between Fuchs and the Application. Fuchs utilizes a built in determinant type of non-slip contact in the form of setscrews 62 that pinch the material in the clamp. This means that the stresses on the work piece and clamp add together for the combined stress graphs in figure 20 which is the sum of the graphs in figures 18 and 19. The clamps are only determinant in the portion of the work piece subjected to the set screw, the portion of the work piece in between the side by side clamps or outside of the set screw clamps will not be determinant and will react differently than what is graphed in figures 13–20, and will not be a pure bending moment.

BENEFITS OF THE APPLICATION OVER FUCHS

Mid material gripping of the Application is better than the edge gripping of Fuchs since mid material gripping allows for a greater variety of bends. Short bends can be made in the middle of a long work piece and multiple bends can be made in one work piece at different locations instead of just one bend over the whole work piece. Mid material gripping can also achieve the same type of bend as edge gripping simply by widening the spacing between the clamps. Mid material gripping allows for smaller torques and forces to be used for the same size

of bending section since the axis of rotation intersects the material and the material's reaction forces do not have as much leverage on the axis of rotation of the clamp. Mid material gripping allows for a greater variety of bend angles to be made, from 0° – 360° depending of the geometry of the mid material grippers, whereas edge gripping clamps will collide soon after 180°.

The pure bending moment of the Application is betted than the axial compression of Fuchs. A pure bending moment imparts a minimum amount of stress to the material and thus a minimum amount of stress concentrations. The stress in Fuchs that is purely compressive does not cause bending and is not required for the bending process, which causes extra total combined stress, extra deformation, and extra stress concentrations. The stress and deformations are only between the mid material gripping non-slip contacts in the Application, while Fuchs has stress over the whole work piece between the edge gripping clamps, and there is compressive stress over the entire work piece including the portion of the work piece in the edge clamps.

The Application is much simpler than Fuchs. The Application has two fewer axis of rotation and one fewer axis of translation. The Application has fewer moving parts and fewer parts total. It has one rolling assembly and one rail rather than two rolling assemblies and two rails. The Application is a more robust design that is more economical and easier to operate.

RESPONSE TO LEESE (3,831,419)

The Examiner cites Leese as a reference that covers the same material as the Application and teaches the same method. The Applicant denies that Leese covers the same material as the Application and denies that Leese taught the same method that the Application claims. Leese is

drawn to a machine and method that bends panels 180° using edge gripping torque members and partially rotating them using winch pulled levers to form half cylinders and half cones. The torque members move closer together as an incidental function of a decreased transverse dimension of the curved panel.

SPECIFICATION OF LEESE

Leese specifies a machine for transversely curving elongated panel into half cylinders or half cones. Pairs of wheeled carriages having vertical pivots are movable toward and away from each other between adjustable stops that are used "to facilitate a certain amount of over-bending of the panel" (column 4 line 38-42). Edge gripping torque members are either parallel or convergent/divergent and are connected to the rolling carriages. This is not the type of bending that is claimed by the Application. The Application does not have an extra vertical pivot axis and does not use edge gripping and does not use torque couples that are not parallel to each other. Forced outward pushing of the torque couples by adjustable stops during bending is not a pure bending moment, and the Application does not use that type of bending.

The edge gripping channels 21 on the torque members in drawings 4, 6, 7, 8 and 9 have different length legs 21a and 21b which means that the forces transferred to the work piece in the gripped section will be shear stresses without the support of a built-in fixed determinant gripper that would prevent displacement in the gripped portion of the material. The "channels 21 have upper flanges 21a which are spaced transversely further apart than their lower flanges 21b" (column 2 line 66-column 3 line1). This means that there will be two offset forces perpendicular to the axis in the gripped portion of the material that will create shear forces in the gripped

portions of the work piece. This is depicted in the diagrams of the reaction forces below in figures 26 and 32.

A pair of double arm levers 26 are attached to the torque members 19 and the ends of the levers have pulleys 27 on top and pulleys 28 on bottom. Cables extend around the pulleys on the levers and frame and go to a common winch-pulling source 35 that is not drawn, and pulling source 35 is shown being pulled in two opposite directions at the same time. Drawing 1 of Leese is not completely drawn and it is confusing as can be seen in figure 22. Leese merely specifies

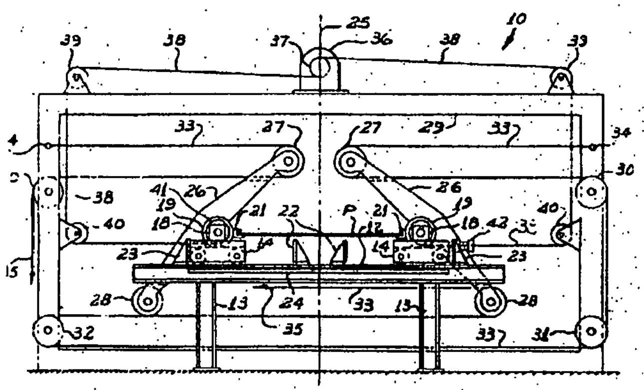


FIG. 1
Figure 22. Drawing 1 of Leese.

that "the pulling source may be a suitable winch" (column 3 line 45-46), but does not describe how the cables are routed to a winch, where a winch could attach to the machine, or how the winch could pull in two opposite directions at the same time. As the levers are rotated and the panel bends, "the torque members 19 will automatically move closer together while the carriages 14 move toward each other along the rails 12" (column 3 line 57-60).

Leese erred by specifying that an auxiliary winch for returning the levers and torque members to their original position has "a drum 37 with cables 38 windable in opposite directions on the drum" (column 3 line 64-66). The cables 38 would not need to be windable in opposite

directions on the drum, and the winch would not work as described and drawn if the cables 38 were wound in opposite directions around the drum. Leese further erred by specifying power cylinders to initially move the carriages inward to seat the work piece in the torque members, since the inward movement would cause the lever to rotate due to the friction of the cables and pulleys and since the only thing to resist the rotation of the levers is the work piece, and the work piece is not fully engaged at this point. The rotation would likely be small, and the work piece being forced into the channel may rotate it back horizontal, but it probably would not work well and the channel would have to be designed with some play in it.

The rolling carriages and rails are not designed to resist upward vertical forces, only downward forces. The machine cannot be run in reverse. The variety of bends that Leese can produce is limited by the vertical placement on the frame of the pulleys 30 and 32 and the anchor 34 and the common pulling source 35 since the lever pulleys 27 and 28 cannot be pulled by the cable to a location that is vertically below the level of the cable attachments to the frame, since the cable would then pull the rolling carriages up and off of the rails. As can be seen from the drawing of Leese in figure 23, the levers also cannot rotate to an angle that is past the point

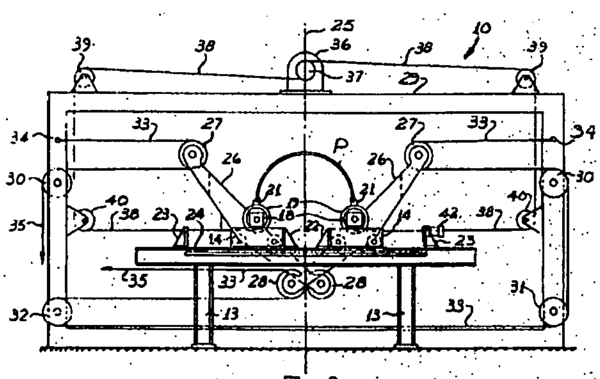


Figure 23. Drawing 2 of Leese.

where the levers point at the pulleys, since the tension on the cable will not allow it since the

cable will be the shortest and drawn the most around the winch 35 at the angle that the levers point at the pulleys. Rotation of the lever past the angle where the lever points at the pulley would cause the lever to then pull on the cable and the cable would be unwound from the winch, and there is no force applied to the machine that could rotate the levers past the angle that levers point at the pulleys. The machine of Leese is only designed to make 180 degree bends, while the Application can make bends from 0 degrees to almost 360 degrees.

Drawings 7, 8, and 9 of Leese have "offset channels on the torque members so that they are somewhat tangential rather than radial" (column 5 line 15-17). These types of off axis clamps are similar to those in Fuchs and impart compression forces and an imperfect bending moment to the work piece. This creates unnecessary and extra stress concentrations in the work piece. The Application uses a pure bending moment in the absence of extra compressive stresses.

As can be seen in figure 24, drawing 3 of Leese shows that the rails 12 are not connected to the frame 29. Nowhere does Leese specify or claim that the rails 12 are connected to the

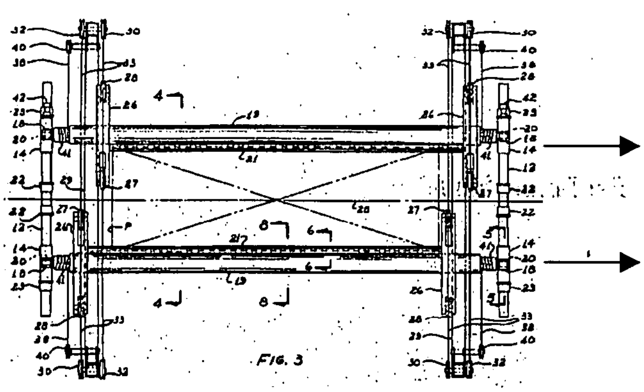


Figure 24. Drawing 3 of Leese.

frame 29. This means that the machine of Leese could not resolve any reaction forces that are produced in the direction along the torque members 19 between the rails supporting the torque

members and the frame supporting the pulleys and winches. Reaction forces in this direction would be created during the bending of half cones or any other type of bending where the torque members are convergent or divergent or not perpendicular to the frame. The reaction forces would be created by the tension on the cables pulling on the levers 26 in a direction that is not perpendicular to the torque members, and also from the bending forces not being applied to the work piece perpendicular to the elongate axis.

Leese does not specify a bending moment or a pure bending moment, but the machine that Leese describes could be used to create a pure bending moment as a special solution of the machine and special arrangement of the parts of the machine. Leese does describe free reduction of the space between the torque members as the material bends. Leese specifies edge gripping the work piece which will only allow bending over the entire work piece while the Application uses mid material gripping of the work piece which also allows for smaller radius bends to be placed within the work piece between the two edges. Leese does not specify that the rate of bending is constant and does not specify that the torque is constant, as does the Application. Leese uses two rails, four rolling carriages, four vertical pivots, and a bunch of pulleys and cables. The Application uses only one rail and one rolling carriage. The Application is much simpler than the machine specified by Leese.

CLAIMS OF LEESE

Leese claims cover two machines, claims 1-9 being drawn to the first machine and claims 10-16 being drawn to the second machine. Both machines claim a pair of rails with rolling carriages with elongated torque members with edge gripping channels and winch pulled levers

attached to the torque members. Torque members rotate oppositely and concurrently moving the torque members toward each other as a function of the decreased transverse dimension of the curved panel, and pivot in vertical pivots in the rolling carriages for convergent or divergent movement of the torque members. The second machine adds adjustable stops, offset channel edge grippers, power cylinders to initially seat the work piece, and a return winch that also rotates the levers back to the starting position.

Leese claims machines and the Application claims a method. Leese does not claim a bending moment or a pure bending moment as the Application does. Leese does not claim that the rate of bending is constant and does not claim that the torque is constant, as does the Application. Leese does claim free reduction of the spacing between the torque members as the work piece bends. Leese claims edge gripping with offset contact points on the clamp, which is not the type of mid material gripping non-slip contacts that the Application uses. Leese claims an extra vertical axis that is not required for a pure bending moment that allows the torque members to not be parallel which is not the type of bending that the Application claims. Leese does not claim clamp configuration as to whether or not the axis of clamp rotation intersects the elongate axis of the work piece, and the specification described off-axis edge gripping channel configurations in drawings 7, 8, and 9 of Leese.

ANNALYSIS OF LEESE

<u>PURE BENDING MOMENT ONLY A SPECIAL SOLUTION</u>

Leese can only create a pure bending moment as a special solution of the machine in which the torque members 19 are parallel to each other and the channel 21 is positioned on the torque

member such that the axis of rotation of the torque member intersects the axis of the elongate material as in drawings 1, 2, and 4 of Leese; but this configuration was not specified or claimed and can only be guessed as possible from the drawings. This type of bending moment would only be a pure bending moment in the portion of the work piece between the channels. The portions of the work piece in the channels would be subjected to shear stresses due to the geometry of the channels and due to the channels not being a secure built-in type of material gripping. Further, this type of bending can only form bends over the entire work piece, it cannot form small radius bends over small sections of a long work piece as the mid material gripping Application can. The differences between the bending forces in Leese and the Application will be more easily discernable from the diagrams of Leese drawn below. These diagrams are drawn to the special solution of Leese that could produce a pure bending moment as discussed above.

DIAGRAMS OF LEESE

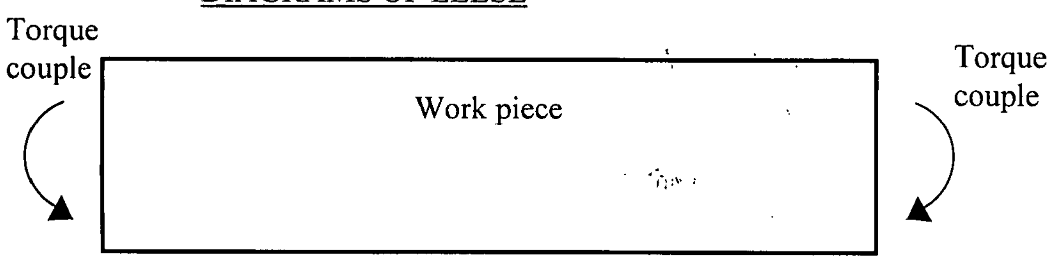


Figure 25. Work piece with two opposite torque couples with axis of rotation intersecting the elongate axis of the work piece, but not intersecting the material, creating a bending moment in the work piece.

Figure 26. Due to the shape of the clamps, the torque couple is transferred to the material in the form of two offset pairs of forces.

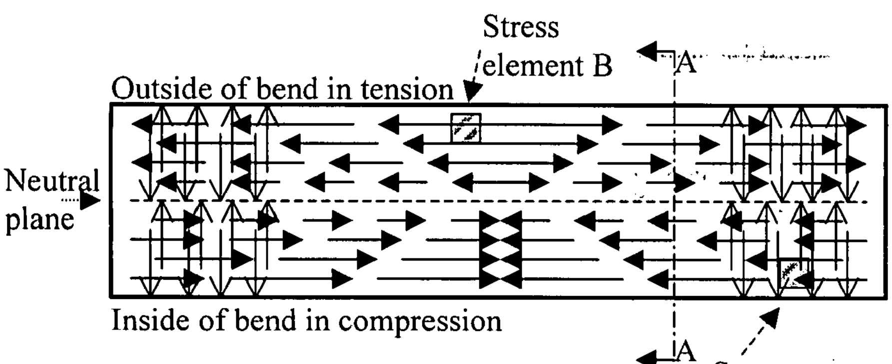


Figure 27. Direction of stress and plastic deformation in the work piece. There are shear stresses in the clamped portions.

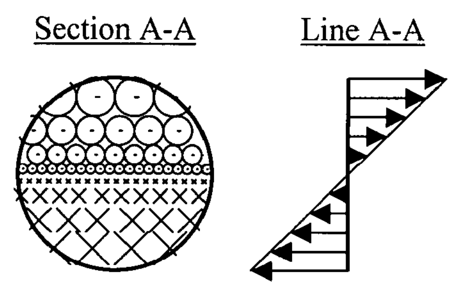


Figure 28. Distribution and magnitude of stress and plastic deformation over the cross section.

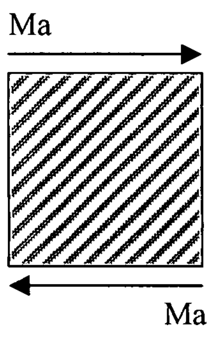


Figure 29. Stress element B from figure 27. In the section of the work piece between the clamps there is only a pure bending moment Ma.

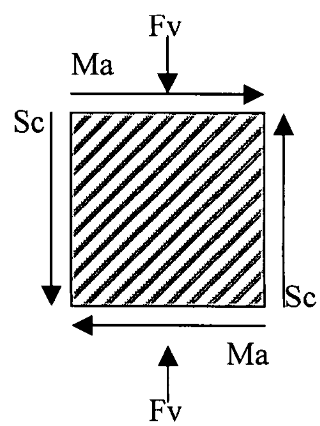


Figure 30. Stress element C from figure 27. In addition to the bending moment stress along the axis Ma, there is also vertical compressive stress Fv and Shear along the cross section Sc in the clamped portions of the work piece.

Figure 31. Leese's Work piece with edge gripping clamps (cross hatched) applying torque couples.

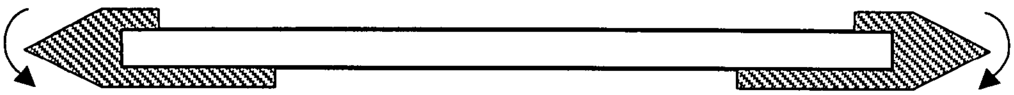


Figure 32. The reaction forces and shear and bending moment stress graphs of Leese of the work piece in loose clamps.

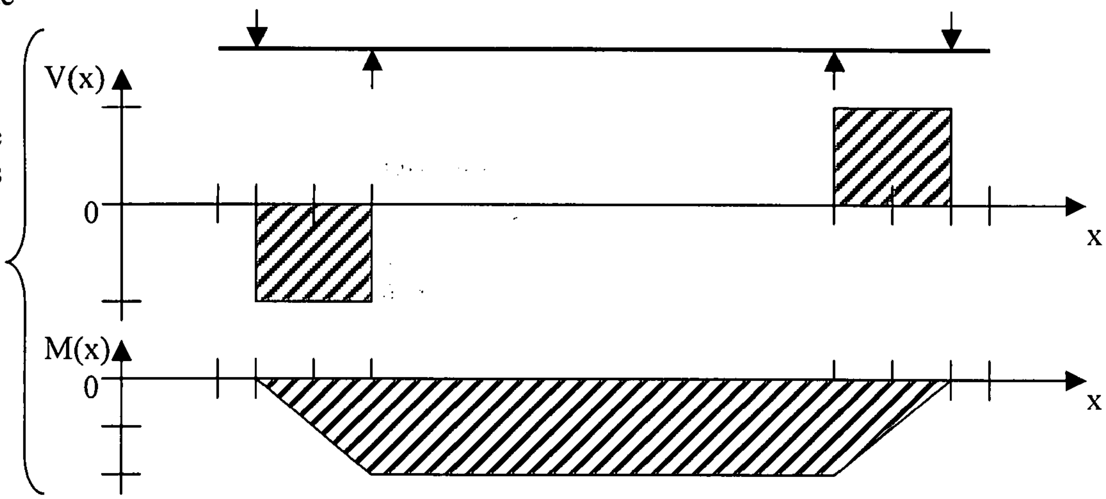
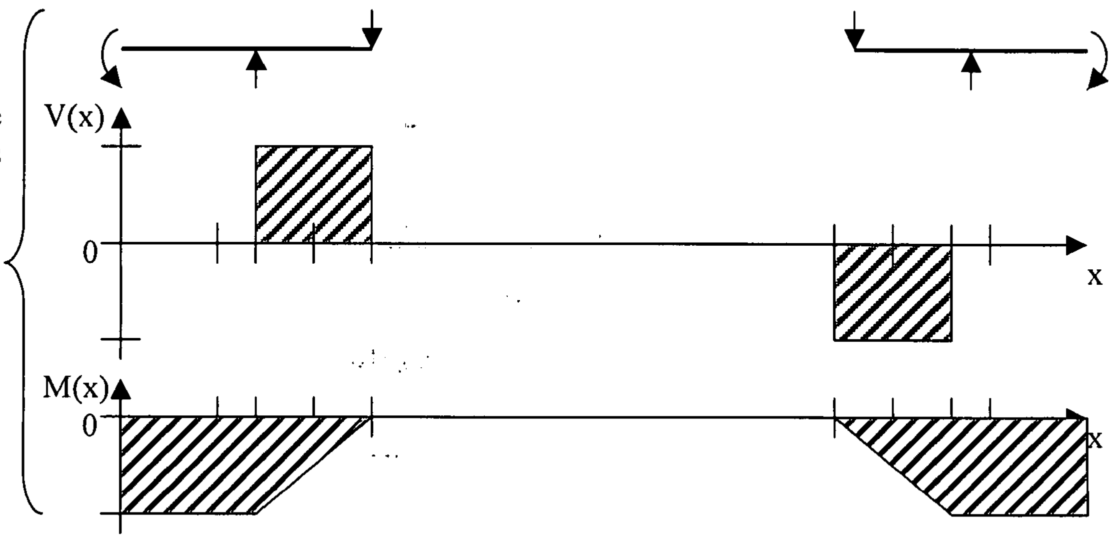


Figure 33. The reaction forces and shear and bending moment stress graphs of the edge gripping clamps of Leese.



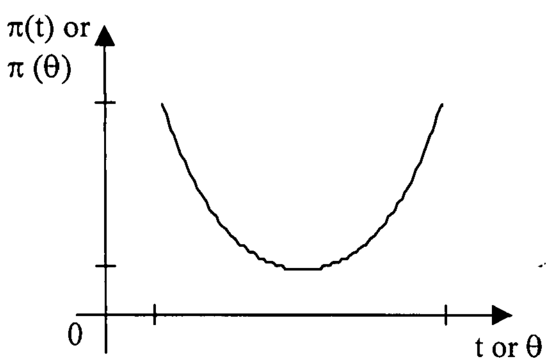


Figure 34. Graph of the rate of bending of Leese.

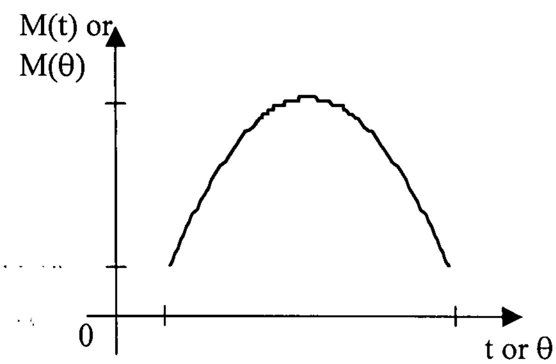


Figure 35. Graph of the bending moment stress over time of Leese.

EDGE GRIPPING ASYMETRIC NON-DETERMINATE CONTACTS

Figure 25 is a diagram of the work piece in Leese being subjected to opposite torque couples through edge gripping channels. This is also pictured in figure 31. Figure 26 shows the reaction forces on the work piece. The opposite torque couples react on the work piece by focusing the torque into the locations that there are arrows representing the reaction forces on the work piece. This is due to the geometry of the channels not being symmetrical where they contact the material and due to the channels having no means of fixably or tightly gripping the work piece, but the channels are designed with a "space 21c between the flanges 21a and 21b of the channels is sufficient to accommodate the thickness of the... out-of-plane waviness of the panel edges" (column 3 line 6-10) such that the work piece can be slid into the channels by power cylinders pushing on the carriages. Thus there is play in the contact area between the channel and the work piece and the work piece would have slight rotation in the channel such that the force of the torque member rotating would be resisted only at the point of the arrows in figure 26. This is also due to the bottom flange of the channel being longer than the top, each flange conducting the force of rotation to the work piece at the inside edge of the flange, which are at the points of the arrows representing reaction forces in figure 26.

Figure 27 is a diagram of the same work piece of figure 25 that shows the direction and magnitude of the lines of force and plastic deformation in the work piece. The bending stress, and hence the lines of force and deformation, is from almost edge to edge due to the edge gripping channels 21. There is also shear stress in the work piece in the portion of the material in the edge gripping channels. It is easily apparent that the lines of force of the Application in figure 2 are different than those of Leese in figure 27, specifically in the contact areas subjected

to gripping. The lines of force in the Application do not extend all the way to the edge of the material, but only from the center of one torque couple to the center of the other torque couple. Also, there is no shear stress in the Application, so the lines of force are all along the axis rather than transverse to it. Figure 27 also shows section lines A-A and stress element B and C. The stress elements should be considered as being in the vertical plane of the center of the round stock, and not on the surface of the round stock. Element B is in the bending zone between the torque couples, and Element C is in the edge gripped portion of the material.

Figure 28 shows the direction and the magnitude of the lines of force and deformation across the cross section at A-A in figure 27. The X's in figure 12 are the tail end of arrows pointing into the cross section and the circles are the heads of arrows coming out of the cross section. Figure 29 is a diagram of the stress element B from figure 27. There is moment stress Ma at element B which is in the bending section of the material between the edge gripping torque members 19. Figure 30 is a diagram of the stress element C from figure 27. There is moment stress Ma, Vertical compression stresses Fv, and shear stresses along the cross section Sc. The stresses on an element add to each other to create a combined stress on the element. The more stresses applied to the element the greater the combined stress on the element. The element in figure 6b of the pure bending moment would have less combined stress on it than the stress element C in figure 30 since there are fewer stresses applied to it.

Figure 31 is a drawing of the work piece and of the channels 21 on the work piece and the torque couple on the torque members 19. Figure 32 is a diagram of the reaction forces on the work piece. It can be seen that the reaction forces line up with the inside edges of the flanges of

channel 21. Figure 32 also has graphs of the shear stress and bending moment stress of the work piece. It can be seen that there is shear stress in the portion of the work piece that is between the

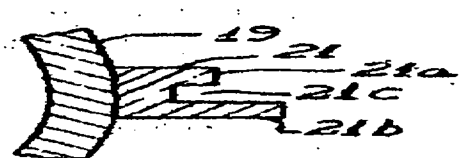


Figure 36. Drawing 6 of Leese.

inside edge of the top flange 21a and the inside edge of the bottom flange 21b, which is also pictured in figure 36 which is drawing 6 of Leese. The shape of the bending moment stress graph also corresponds to the geometry of the channels 21. The bending moment starts a t zero at the inside edge of flange 21a and increases linearly to the inside edge of the bottom flange 21b and then is constant along the elongate axis until it reaches the other channel where it then decreases in magnitude from the inside edge of the bottom flange to the inside edge of the top flange.

Figure 33 is a drawing of the reaction forces on the clamps, consisting of the torque members 19 and the channels 21, simply represented by one horizontal line each. The reaction forces toward the inside resist the torque couples toward the outside. Figure 33 also has shear stress and bending moment stress graphs of the clamps that depict the differences between Leese and the Application. Since the channels non-determinant and are not a built-in non-slip contact, the stresses of the work piece and the stresses of the clamps will not be added together as they are in the Application and in Fuchs. The channels do not resist the deflection of the work piece in the contact area because there is play in the channel contact area, and because the smaller top flange 21a does not resist the upward deflection of the work piece between the inside edge of flange 21a and the inside edge of flange 21b. This is why there are shear stresses in Leese and

not in the Application. Even if the machine of Leese were redesigned with built-in non-slip contacts, the stresses add together to form a bending moment stress from edge to edge of the material that can only form bends over the entire work piece and cannot be used to form multiple smaller radius or different radius bends within the length of the work piece as the Application does.

NON-CONSTANT BENDING MOMENT AND BENDING RATE

As can be seen by comparing drawings 1 and 2 of Leese pictured above in figures 22 and 23, the work piece is bent by the levers 26 being pulled through an arc by cables 33 from the stationary pulleys 30. The arc has a center in the lever's axis of rotation in the bearing blocks 18 connected to the torque members 19 and the arc has a radius length the same as the length of the lever 26. The angle between the cable 33 and the lever 26, and hence the angle of the force pulling on the lever 26, changes as the lever is pulled through its arc as depicted in figure 37. Since the angle of the force pulling the on the lever changes, the amount of the force perpendicular to the lever and tangential to the arc changes, and thus the torque the lever create changes and the rotational rate the lever swings through the arc and rotates the torque member changes.

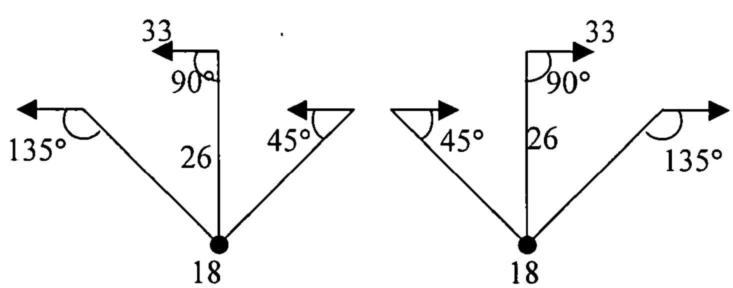


Figure 37. Diagram of the angles between cables 33 and levers 26 of Leese as the levers rotate.

Since the torque the torque members transfer to the work piece is changing, the bending moment stress in the work piece continually changes in magnitude during the bending process as depicted in figure 35. The rate of deformation and the rate of bending changes throughout the bending process since the rate of the angular and rotational displacement of the torque members are changing as depicted in figure 34. The bending process is first rapid displacement with a weak bending moment, then slow displacement with a strong bending moment, and finally rapid displacement with a weak bending moment.

The rate of rotation Vr of the lever 26 and the torque member 19 is found by the equation: $Vr = Vc/(R*\sin\theta)$ where Vc is the rate the cable 33 is pulled, R is the radius of the lever 26, and θ is the angle between the cable and the lever. The angle starts at about 45 degrees and stops at about 135 degrees. Since Vc and R are constant, Vr varies as a function of $1/(\sin\theta)$ and starts at about $1.414*(Vc/R)$ at 45 degrees, then decreases to a minimum $1*(Vc/R)$ at 90 degrees, and then increases back up to about $1.414*(Vc/R)$ at 135 degrees. The rate of rotation Vr is directly related to the rate of bending $\pi(t)$ of the work piece, and Vr has the same graph as $\pi(t)$ above in figure 34.

The torque T on the torque member is found by the equation: $T = F*R*\sin\theta$ where F is the tension on the cable 33, R is the radius length of the lever, and θ is the angle between the cable and the lever. The angle starts at about 45 degrees and stops at about 135 degrees. Since sin 45 = 0.7017, the torque starts at about 70.71% of maximum at 45 degrees, then increases to maximum at 90 degrees, and then decreases back down to about 70.71% of maximum at 135

degrees. The torque T is directly related to the bending moment M(t) in the work piece, and T has the same graph as M(t) above in figure 35.

The changing bending moment stress in the work piece of Leese causes the work piece to be more fatigued since it under goes multiple bending cycles: fast and weak, then slow and strong, and then fast and weak. Leese has less control of the bending stresses and the rate of deformation of the material, which may limit the types of work piece materials and bend types; such as some memory metals or some plastics, which would require a constant torque at a specific magnitude and/or at a specific rate of deformation. Leese also has less control over the heat caused by internal friction due to deformation during the bending operation, which would be bad for working with materials that are near their melting point.

BENEFITS OF THE APPLICATION OVER LEESE

The mid material gripping non-slip contacts of the Application are better than the edge gripping of Leese. Non-slip contacts allow for a better distribution of stress in the work piece such that there are no shear stresses in the work piece. Since the Application uses non-slip contacts that tightly hold the work piece, the Application has a bending moment stress that is constant in magnitude along the elongate axis from the center of rotation of the one gripper to the center of rotation of the other gripper, and zero every where else. Leese has a bending moment stress that is not constant in magnitude along the elongate axis of ht work piece that starts at zero and increases along the portion of the work piece in the channel and then is constant to the other channel, and then it decreases along the portion in the other channel to zero. The different

stresses create uneven bending along the elongate axis of the work piece. Leese also has shear stress in the portion of the work piece in the channels.

The Application allows for a greater variety of bend radii and bend location. The Application can perform all of the bends of Leese as well as bends that Leese cannot perform. The Application can perform short bends in the middle of a long work piece while Leese cannot. The Application can create multiple short radius bends in one long work piece while Leese cannot. Leese can only create bends over the complete work piece, which the Application can also do if the mid material gripping clamps are spaced far apart on the edges of the work piece, but the axis of rotation would still intersect the material and the elongate axis.

The Application allows for a greater angle of bends to be made. Leese is designed and specified to only produce 180 degree bends to form half cylinders and half cones. The Application is designed to be able to make bends from 0 degrees all the way to almost 360 degrees depending on the geometry of the mid material clamps. The machine of Leese could not be used to make greater bend angles since the edge gripping torque members would collide soon after 180 degrees.

The Application's constant bending stress and constant rate of bending is better than the changing torque and changing bending rate of Leese. The Application will introduce less fatigue into the work piece, meaning that the work piece will be stronger. The Application has more control on the bending stresses and deformation rates. The Application also has more control over the heat caused by internal friction of the work piece during the bending process.

The Application is much simpler than Leese. Leese has two rails and two frames, while the Application has only one rail that also acts as the support frame. Leese has four vertical pivots while the Application has none. Leese has four rolling carriages while the Application has one. The Application has fewer moving parts and fewer parts total. The Application is a more robust design than Leese and is more economical and easier to use.

ERRORS IN THE OFFICE COMMUNICATION OF 5-30-2007

The Examiner erred on page 2 of the Office communication of 5/30/2007 by calling the channels 21 of Leese non-slip contacts. The channels of Leese as specified are wider than the thickness of the work piece to account for possible waviness of the work piece, and the channels as specified and claimed are sufficiently wider than the thickness of the work piece to allow the work piece to slide into and out of the channels for seating and removing the panels. There is some amount of play in the channels 21 and there is no mechanism for securely gripping the panels like set screws, and they are not non-slip contacts.

The Examiner erred when he described Leese by stating "no stresses are placed on the elongate material during the bending process other than the pure bending moment" (page 2-3). Leese only creates a pure bending moment as a special solution of the machine, and the bending moment is only pure in the portion of the work piece between the inside edges of the bottom flanges 21b. The portions of the work piece that are in the channels 21 will be subjected to shear stresses and impure bending moments.

The Examiner erred when describing Fuchs as having "torque couples 12" (page 3), but Fuchs never describes 12 as being torque couples, but calls them "rotary arms" (column 2, line 44). The rotary arms 12 swing through an arc and transmit stress to the work piece that is compressive and an impure bending moment. The Examiner also quotes Fuchs at column 4 line 46-53, but this statement by Fuchs is confusing and the last half of it makes no literal sense.

The Examiner erred when describing Fuchs by stating "the bending of the elongate material 10 is produced by a pure bending moment" (page 3). This is false. Fuchs does not claim or specify that a pure bending moment is used. The machine of Fuchs cannot be used to create a pure bending moment since it uses primarily compressive forces.

The examiner also erred by stating "no stresses are placed on the elongate material during the bending process other than the pure bending moment. This is evident by the... equal and opposite couples" (page 3). The bending moment is not pure. There are other stresses on the work piece including axial compression forces across the cross section and along the whole work piece. The equal and opposite couples are off-axis and do not intersect the elongate axis of the material and thus do not create a pure bending moment.

The Examiner erred in denying claims 1 and 2 of the Application based upon the references of Fuchs and Leese. The Application is not taught by the references and should not be rejected on those grounds. The Application should be allowed.